Review for the
Grain Inspection, Packers and Stockyards Administration's (GIPSA)
Texas Fed-Cattle Investigation

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As a result of increasing concern in the meat packing industry about the effects of captive supply contract arrangements on spot market prices and profitability among cattle feeders, the Grain Inspection, Packers and Stockyard Administration (GIPSA) undertook a number of studies to investigate the effects of captive supply arrangements on fed-cattle markets. This report reviews one such study conducted by John R. Schroeter and Azzeddine Azzam, "Captive Supplies and Spot Market Prices for Fed Cattle in the Texas Panhandle", submitted in fulfillment of USDA GIPSA cooperative agreement No. 98-PPD-01, titled "Econometric Analysis of Fed Cattle Procurement in the Texas Panhandle."

GIPSA's charge to reviewers is:

> Analyze the quality of the output and associated analyses to determine if appropriate methods and procedures were employed. Assess whether GIPSA asked the right questions, and used appropriate analytical models to answer critical questions. Make suggestions and recommendations about additional analyses, data, or questions that may strengthen the investigation being reviewed or enhance our ability to investigate these critical questions. Reviewers will provide independent assessments of their findings and recommendations rather than developing a consensus report. (GIPSA)

Investigation Summary

The investigation seeks to "determine whether procurement of cattle by packers during the period of the investigation is associated with potentially unfair, unjustly discriminatory, or deceptive practices to the detriment of livestock producers," (Schroeter and Azzam, p. 9). To answer this question, the authors use econometric models to "measure the use and effects of noncash purchases on prices paid for fed cattle." In addressing this issue, the authors posed and sought answers to four related questions:

> 1. Who is responsible for deciding how many captive supply cattle will be delivered to a packing plant within any given time period? How far in advance of delivery is that determination made?

2. What is the empirical relationship between the use of captive supplies and spot market prices?

3. What economic mechanisms could be behind the empirical relationship?

4. Does the nature of the base price in the formula used to price marketing agreement cattle influence a packer's spot market pricing conduct? (Schroeter and Azzam, p. I1).

To answer these questions, the authors review existing studies, specify theoretical and econometric models, estimate unknown model parameters and conduct hypothesis tests. Data used in the empirical investigation were collected by GIPSA and contain transaction information on cattle procurement activities of four large beef packing plants in the Texas Panhandle region over the period from early February 1995 through mid-May 1996.

Major Findings

Question 1

To address question 1, GIPSA personnel interviewed feedyard owners and managers about business operations. From these reports, the authors concluded that the number of cattle delivered within a given week by a feeder to a packing plant under a marketing agreement is generally determined by the feeder. Packers have discretion over specific days of delivery.

Question 2

To address question 2, empirical analyses were conducted at the plant and regional levels. At the plant level, the researchers found "packers who expect 'large' volumes of captive supply deliveries in the near-term future *do* tend, other things equal, to pay "low" spot market prices relative to regional averages" (p. 9). At the regional level, the authors found "[c]aptive supply usage and contemporaneous spot market prices are negatively related..." (p. 4). The economic significance of the regional effect of the captive supplies on price was found to be "reasonably substantial" (p.9). At the regional level, the authors found that a one standard deviation increase from mean in the volume of captive supplies results in a $0.69/cwt decrease in the spot price. At the plant level, a one percent increase in the captive supply proportion of near-term future slaughter results in about a $0.20/cwt reduction in the spot market prices paid by that plant. These results are found to be generally consistent with the findings of previous studies reviewed by the authors.

Question 3

In considering question 3, the authors focus on answering a slightly different question than that originally proposed: "is the negative correlation between captive supply purchases and cash price evidence of a casual relationship between captive supplies and cash price?" The authors argue that the negative correlation results from packers and feeders intertemporally shifting captive supply deliveries in response to economic incentives dictated by changing market conditions. In particular, they argue

> deliveries of marketing agreement and forward contract cattle will tend to be "high", other things equal, when the *ex ante* forecast of the spot market price is "low." Since market participants are likely good price forecasters, their *ex ante* forecasts are likely to be correlated with *ex post* price realizations. As a result, the tendency for weekly captive supply deliveries to be negatively correlated with unobserved *ex ante* one-week-ahead price forecasts could be revealed as a negative correlation between weekly captive supply deliveries and the observed *ex post* price realizations (p. 6).

Following this line of reasoning, the authors conclude

> [t]he tendency for spot market cattle prices to be "low", other things equal, in weeks in which captive supply deliveries are "high", does not necessarily mean that there is an underlying mechanism whereby large deliveries of captive supply cattle in a particular week cause that week's spot market price to fall (p. 7).

Question 4

The authors hypothesize that when the base price is derived from a USDA reported price, "there would appear to be little, if any, capability on the part of the packer to manipulate the formula base" (p. 7). However, when the base price is derived from plant-level average cost, "[t]he possibility exists that packers might manipulate the base through strategic conduct in their spot market (non-formula) purchases the previous week" (p. 7). The authors find econometric results do not support the hypothesis that packers try to manipulate formula prices through their spot market purchasing strategies.

Finally, the authors recommend

> that the agency should not rely on the statistical finding of a negative correlation between captive supplies and spot market prices as evidence of intent by packers to depress cattle prices through the use of captive supplies, or as evidence of the unintentional consequence of lower prices as a result of captive supply use. (p. 42).

The authors do recommend several cautions. In particular, they note that basing formula prices on "in-house" average hot cost, rather that on USDA reported prices, potentially opens the door to packer price manipulation through spot market conduct.

Review

Generally, the questions posed by GIPSA and those investigated by the authors address the important issues concerning the effects of captive supply arrangements on spot market prices. Also, the report is well written and generally fulfills the research objectives set out in the statement of work detailed in the cooperative agreement. The review comments that follow are primarily concerned with: 1) broadening the analysis to consider additional theoretical literature relating to vertical integration, 2) considering additional empirical analyses and resolving econometric issues that may strengthen the results, and 3) considering a broader interpretation of the empirical results.

Additional Theoretical Literature

As the authors explain, the literature cited in the study shares a common objective: to empirically estimate the effect of packer slaughter cattle purchases through captive supply arrangements on spot market price. With the exception of Azzam (1998), little attention is given to literature that develops formal theoretical models that characterize the economic incentives and market consequences of captive supply purchases on the market.

In the cattle industry, captive supplies typically include cattle that are packer-owned or cattle procured through forward contracts or long-term marketing agreements. With the exception of forward contract cattle, this definition corresponds closely with the industrial organization tradition that defines an upstream or downstream firm as vertically integrated if it directly or indirectly controls decisions made within the vertical structure. In the case of packer-fed or packer-owned cattle, production decisions are clearly controlled by packers. To a lesser degree, the same may be said of packers' control of production decisions for cattle procured through marketing agreements.

Marketing agreements are typically long-term exclusive sales agreements under which a cattle feeder agrees to market a specified number of cattle per specified time period (week, month, or year) (Ward *et al.* p. 2). Marketing agreements maybe written or verbal and often last for a decade or more. Marketing agreements generally require the contracting feeder to sell a minimum portion of total production, often 80% or more, to the contracting packer. Prices are usually based on an agreed-upon formula, with the timing of weekly deliveries determined by feeders. Hence, while packers do not directly control contract production decisions, they do restrict feeders marketing options and, in particular, they require the feeder to sell most production to the contracting packer. These restrictions may give packers enough control over

sales made through marketing agreements that these sales might be reasonably viewed as weak forms of vertical integration.

This has potential implications for the analysis of captive supply arrangements in the slaughter cattle market. For example, in a recent paper, Love and Burton (1999) extend Perry's (1978) model of a monopsonist's backward integration into a strategic input market and find a number of theoretical predictions that are consistent with empirical relationships commonly uncovered in investigations of captive supply effects in fed cattle markets. In particular, Love and Burton find that with incomplete backward integration, defined as long-term contracting for a portion of input supply, a dominate processor potentially can benefit from efficiency gains of expanded output and from a price reduction for input supply purchased externally in the spot market. Also, they find a rise in the proportion of input supply firms with which a dominate processing firm contracts results in a fall in the equilibrium external spot market price for the input and a rise in the packer's optimal contracted input quantity. These results generally follow from third-degree price discrimination where the processor pays contract input suppliers a higher price than is paid for inputs purchased in the spot market. Further, the model predicts that, in equilibrium, the spot market price will be lower than the contract price and vertical integration (contracting) will be incomplete.

Emons (1996) has analyzed the decision to vertically integrate using a different approach. In his model, downstream firms either produce the intermediate good themselves (contract) or purchase it through a spot market from unintegrated upstream firms with no market power. To produce the input, a firm has to build up capacity at a fixed cost. A game ensues in which both upstream and downstream firms simultaneously select input production capacities. Nature then determines the downstream firm's input requirements (derived from stochastic consumer demand) and input price is determined in the spot market.

Emons' model predicts that downstream firms will always integrate, but integration will be incomplete. Furthermore, as downstream firms start producing (contracting) some of their input needs, aggregate demand in the market is reduced and spot prices in the input market are reduced. The model predicts that the incentive to depress spot market prices frequently leads to inefficiently high levels of vertically integrated capacity.

Using a similar model, McLaren (1997) finds that spot market price unambiguously rises with the number of downstream firms purchasing from independent (unintegrated) suppliers. Because input price is determined by its most attractive alternative use, it is determined by the value of the "runner-up" bid. As a result, adding one more independent buyer and seller may either result in a new bid for an existing input that is higher than the incumbent bids, thus raising the equilibrium price of that input, or have no effect. The least effect of adding one more independent buyer and seller in the cash market is to leave the equilibrium spot market price unchanged. Often, adding one more unintegrated buyer and seller will result in a rise in the equilibrium spot market price.

Each of these models predicts that vertical integration, or contracting, can have a depressing effect on spot market input price in markets characterized by partial vertical integration. They also suggest that the effect of contracting on spot market price is more closely related to long-run decisions, specifically how much input capacity to secure through contracting or ownership, than it is to very short-run fluctuations in input supply sourcing from contract or spot markets.

These predictions raise a number of issues that are not addressed in the Texas Fed-Cattle Investigation. First, are there systematic differences in quality adjusted contract-priced and spot market-priced cattle? Perry's, Love and Burton's, and Emons' models predict that if packers use captive contract supplies strategically, then contract price will exceed spot market price for the same quality of cattle. Ward *et al.* find some evidence of this in their study. They find "[p]rices for cattle purchased via marketing agreements were \$0.07-\$0.10/cwt higher than transaction prices for cash-purchased cattle" (p. 81). While this difference is not large, it appears to be persistent. It would be interesting to know if such price differences are also evident in the Texas Panhandle data.

Second, the analysis is too narrowly focused on the short-run. Both the empirical model and theoretical arguments motivating the empirical specification are focused on market behavior occurring within a one month or shorter time horizon. Each theoretical paper discussed above suggests that the important effects of noncash transactions made through vertical contracting result from the decision as to how much input capacity to secure through contracting or ownership versus how much input to purchase through spot market transactions. This would indicate the need for a longer period of study, a period long enough to ensure that the volume of cattle sold through contracts changes for a sustained period. Further, additional variables should be included in the empirical model specification to reflect long-term contracting decisions.

The potential importance of including variables reflecting long-term contract decisions is evident in the data and empirical model estimation results. In the data, the average plant-level FOB cash market transaction price is lowest for

Similar long-term contracting effects are evident in the empirical model results. Regression results reported for the plant-level analysis indicate that

> [w]ith each 1% increase in the captive supply proportion of a given plant's near-term future steer and heifer slaughter, the spot market prices paid by the plant will fall, on average, by somewhere between \$0.18/cwt. and \$0.22/cwt (p.16).

However, the regression (Table VI.1.1 The live cattle price - captive supply relationship with RATIO defined using planning horizon 1) on which this result is based, includes plant dummy variables. The

While it is possible that these dummy variable coefficients reflect cost efficiency differentials or average quality differences in cattle purchased among the plants, it appears that plant dummy variable estimates most likely reflect differences in purchasing strategies relating to using marketing agreements, packer-fed purchases or cash purchases. Assuming the full dummy variable effect results from purchasing strategy differences suggests that the effect of captive supplies on cash price can be substantially larger than that reported. Furthermore, it appears that captive supply use has both a marginal effect and a mean shifting effect on spot market price. This conclusion is consistent with predictions from the theoretical literature discussed above.

Third, forward contracts appear to serve a fundamentally different purpose than either marketing agreements or packer-fed arrangements. As discussed, because packers exert at least partial control of cattle feeders' production decisions when cattle are procured through packer-fed arrangements and marketing agreements, these contract forms may be best viewed as forms of vertical integration. In contrast, forward contracts may best be viewed as risk management tools. Forward contracts are usually negotiated on a lot-by-lot basis. Under forward contracts, a cattle feeder agrees to deliver cattle at a specified future date. The price is based on a futures market price and an agreed-upon basis. The contract price may be set at the time the contract is written or at some later date before delivery. However, the primary concern appears to be "locking in" a price for the feeder. As result, forward contracting may be best viewed as a risk management mechanism. Packers do not appear to exert influence over production decisions when cattle are purchased through forward contracts. Hence, it appears likely that sales made through forward contracts may have a different influence on cash market price than sales made through marketing agreements or packer-fed arrangements. Because of this possibility, cattle sold through forward contracts should be considered separately.

Additional Empirical Analyses and Econometric Issues

The empirical model has elements relating to both a "structural" specification and to a "reduced-form" specification. However, since the empirical model is not directly linked with any formal theoretical specification, it makes both model specification and estimation somewhat problematic. This would suggest the need for thorough specification testing.

The plant level analysis is based on the following regression:

$$PRICE = \beta_0 + \sum_i \beta_i D_i + \beta_1 RATIO + \beta_2 AMSPRICE + \beta_3 Head + \beta_4 Yield + \sum_c \beta_c Characteristic_c + \varepsilon$$

where PRICE is \$/cwt cash price for each transaction, D_i is a plant dummy variable for each plant, RATIO is the proportion of slaughter accounted for by captive supplies, AMSPRICE is the \$/cwt AMS weighted average steer price, Head is number cattle in the lot, Yield is the lot's total hot weight divided by total live weight, and $Characteristic_c$ is a number of variables representing various characteristics specific to each lot. The authors obtain parameter estimates for the β_js using ordinary least squares (OLS) regression methods.

As estimated, this regression suffers from two potential pitfalls. First, AMSPRICE represents the "average" price of all transactions in the market area for a particular day. In theory, this includes the transaction under investigation. In the best case, AMSPRICE should be considered a stochastic variable that is correlated with the error term ε. In the worse case, including AMSPRICE as an explanatory variable is akin to including the dependent variable among the explanatory variables. In either case, OLS estimation will result in biased and inconsistent parameter estimates. There are two possible fixes. An instrumental variable can be obtained for AMSPRICE and the regression can be estimated using instrumental variables estimation. In practice, this may prove difficult since the dependent variable is at least conceptually a part of AMSPRICE so any variable correlated with AMSPRICE is also likely correlated with ε and therefore cannot be a valid instrument. Alternatively, the regression can be respecified so that the dependent variable is PRICE - AMSPRICE and AMSPRICE is dropped as an explanatory variable. Regression results can now be interpreted as transaction price deviations from the average market price.

The second pitfall relates to the variable defined as RATIO. In interpreting their regression results, the authors argue that, as a consequence market participants' *ex ante* expectations being highly correlated with *ex post* price realizations,

> the tendency for weekly captive supply deliveries to be negatively correlated with the unobserved *ex ante* price expectations could well manifest itself in a negative correlation between weekly captive supply deliveries and the observed *ex post* realizations of price (p.31).

If these propositions are true, then it follows that RATIO should be correlated with the error term in the plant level regression. Again, OLS parameter estimates will be biased and inconsistent. To obtain consistent parameter estimates, an instrumental variable must be found for RATIO and instrumental variable estimation methods must be applied. By applying both OLS and

instrumental variable estimation, the possible endogeneity of RATIO could tested using Hausman's method.

The regional analysis is based on the following regression:

$$Paverage = \gamma_0 + \sum_i \gamma_i week_i + \gamma_1 Q + \gamma_2 Captive\ supply\ deliveries + \varepsilon$$

where Paverage is $/cwt average cash price for the region, $week_i$ are linear and quadratic time trend variables, and Q is the number of steers and heifers purchased weekly in the region. The authors obtain parameter estimates for the γ_js using ordinary least squares (OLS) and two-stage least squares regression methods assuming Q is endogenous. As the authors suggest, "[t]he behavioral interpretation that seems most natural for such a regression is that of a packer demand curve for spot market cattle" (p.17). However, the parameter γ_1 associated with Q is consistently positive. This suggests that the estimation results may actually reflect feeders' supply response. An alternative, more reduced-form specification, would replace the endogenous variable Q with various exogenous variables that potentially affect both feeder supply and packer demand of slaughter cattle.

Using the same arguments as for the plant-level analysis, captive supply deliveries might be endogenously determined with average price. By applying both OLS and instrumental variable estimation, the possible endogeneity of captive supply deliveries could be tested using Hausman's method.

Broader Interpretation of the Results

The authors argue that "the finding of a significantly negative estimate for the coefficient of RATIO does not imply that captive supply use leads to lower prices received by feeders who sell cattle on the spot market" (p.25). In the plant-level analysis they argue that

> the price regression ... includes AMSPRICE, a proxy for the mean distribution of transaction prices, as an explanatory variable. So the estimate of RATIO's coefficient is a reflection of the variable's effect on individual lot transaction prices *holding constant the position of the overall distribution of transactions prices*. The negative estimate has implications only about the "identities" of packers who buy at "low-end" prices and those who buy at "high-end" prices: Other things equal, packers with "high" values for RATIO tend to pay lower-than-average prices while packers with "low" values for ratio tend to pay prices in the distribution's upper tail. The negative estimate of RATIO's coefficient does not mean that spot market prices would increase, on average, if the use of captive supplies were restricted. (p.25)

This interpretation appears faulty. Suppose it is the case that packers with high values for RATIO do pay lower than average prices for slaughter cattle purchased in the spot market. Then, excluding these purchases from the data would have the effect of increasing the mean value of AMSPRICE. As a result, the expected value of individual transaction prices predicted by the plant-level regression would rise. Including AMSPRICE, the mean transactions price, in the regression cannot act to hold constant the position of the overall distribution of transactions prices while at the same time transactions are excluded from the analysis that fall in the lower tail of the distribution. Systematically excluding observations in the lower tail of the distribution will shift the mean of the distribution (AMSPRICE) upward and this will raise the prices predicted by the plant-level individual transactions model.

Another, more formal, argument can also be developed. The identity $f(X|Y,Z) = f(X|Y)$ holds if X and Z are conditionally independent given Y, where $f(X|Y,Z)$ and $f(X|Y)$ are conditional probabilities. (Pearl, p. 83) If X and Z are not conditionally independent, then $f(X|Y,Z) \neq f(X|Y)$. It follows that $E(X|Y,Z) \neq E(X|Y)$. Hence, holding the value of Y constant cannot act to hold the position of the distribution of X constant with changing values of Z unless X and Z are conditionally independent. Now suppose X is individual transaction price (PRICE), Y is AMSPRICE and Z is RATIO. Then the only way that changing values of RATIO cannot effect the conditional density of PRICE is if RATIO and PRICE are conditionally independent. But, PRICE is significantly influenced by RATIO so there is a very low probability that RATIO and PRICE are conditionally independent. Hence, it must be the case that changing the value of RATIO does change the expected value of spot market transactions prices (PRICE). Bessler and Akleman discuss formal ways of analyzing this type of relationships using directed graphs.

Assuming the estimated models are correct, the total cash market price effect of changing the proportion of cattle purchased using captive supply arrangements can be computed by combining results from the plant-level and regional-level empirical models. An interesting exercise is to compute the total difference in cash price that is paid for a representative lot of cattle in the cash market by the firm purchasing the largest proportion of cattle using captive supply arrangements versus the firm purchasing the smallest proportion of cattle using captive supply arrangements. Including cattle sold under forward contracts, marketing agreements or packer-fed arrangements, as the authors do in their analysis, suggests that the largest proportion of cattle sold under captive

the change in cash price, ΔRATIO is the change in ratio (=0.3), and β_i is the coefficient associated with the highest RATIO and lowest RATIO plant in the plant regression. This represents about 5% of the average spot market price during the period under investigation. In other words, using the regression results estimated by the authors suggests that, on average,

However, given the econometric issues discussed above, this is likely not an accurate assessment of the effect of captive supplies on cash price.

In interpreting the results, the authors investigate an additional hypothesis:

> volumes of both marketing agreement and forward contract cattle delivered in a given week tend to be positively correlated with the previous week's spot market cattle price and negatively correlated with the expectation, formed during the previous week, of the present week's price, other things equal. (p.27)

This hypothesis is tested by regressing captive supply quantities on price and period ahead expected price and the authors find only weak support for this hypothesis. However, these results are used to argue that "an observed negative correlation between captive supply deliveries and spot market price is not necessarily evidence of abusive market conduct on the part of packers who utilize captive supplies,"(p. 32) since "if the decision-makers have good forecasting ability, this correlation could manifest itself in a negative correlation between captive supply deliveries and the observed *ex post* realizations of price" (p. 40). As the authors point out, this reasoning is based on a partial equilibrium analysis. Given the important role this model plays in determining the authors interpretation of the empirical results, it would be prudent to fully develop the equilibrium analysis discussed in footnote 29.

However, this entire issue might be bypassed by using directed graphs. As the authors point out, the essential issue in interpreting their results is: "is this negative correlation [between RATIO and price] evidence of a causal relationship between captive supplies and cash prices?"(p.26) Directed graphs provide nonstructural methods that can be used to explore causal relationships among variables. A direct test of the causal relationship between captive supplies and cash prices can be formulated using directed graph analysis.

The empirical analysis relating to Question 4, do packers manipulate the formula base prices through their pricing strategies in spot market purchases, is based on the regression: $RES = \alpha + \beta M + \varepsilon$, where RES is the residuals from a regression of HOTCOST, a lot's total delivered cost divided by total hot weight, on quality variables associated with each lot, and M is weekly volume of market agreement cattle delivered to the plant. The significance level of the parameter estimates for β are generally low, and the authors conclude that "the results do not support the claim that packers try to manipulate formula base prices through their pricing strategies in spot market purchases" (p.38). This conclusion is only weakly linked to the analysis conducted. As the authors point out, "[i]t is conceivable ... that a packer could strategically reduce its formula base price by paying lower spot market prices for cattle *of given quality*" (p.36). This possibility is not tested.

Finally, given the model specification and econometric issues raised in this review, the authors' conclusions and recommendations should be reexamined after the technical issues are resolved.

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